EFFECT OF RESISTANCE BAND INDUCED POST-ACTIVATION PERFORMANCE ENHANCEMENT DURING A SIMULATED BADMINTON MATCH

By

SHUBHAM DHAKA

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SYNOPSIS

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Lakshmibai National Institute of Physical Education, Gwalior

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CHAPTER-I
INTRODUCTION

Badminton is a popular racquet sport that is played by individuals or teams across the world. It originated in British India in the 19th century and has since become an Olympic sport. Badminton is played on a rectangular court divided by a net, and the objective is to hit a shuttlecock over the net and make it land within the opponent's court while preventing them from returning it successfully. The sport requires agility, speed, coordination, and tactical thinking(Sales et al., 2021).

One of the distinguishing features of badminton is its high physical demands. Players need to possess exceptional stamina and endurance to sustain the fast-paced nature of the game. The rallies in badminton can be long and intense, with players constantly moving around the court, performing quick sprints, jumps, and lunges to reach and return the shuttlecock (Sales et al., 2021). The sport places significant strain on the lower body, especially the legs, as players frequently change direction and execute explosive movements. Additionally, players must have strong wrist and arm muscles to generate power and accuracy in their shots, particularly in smashes and clears. The combination of speed, agility, endurance, and strength makes badminton a physically demanding sport that requires athletes to maintain a high level of fitness and conditioning (Phomsoupha & Laffaye, 2014).

Enhancements in (sometimes maximal) voluntary force production detected several minutes after high-intensity muscle contractions are also observed, which are also most prominent in muscles with a high proportion of type II fibers. This effect has been considered to reflect PAPE(Tillin & Bishop, 2009). Nonetheless, the time course of myosin light chain phosphorylation (underpinning “classic” PAPE) rarely matches that of voluntary force enhancement and, unlike PAP, changes in muscle temperature, muscle/cellular water content, and muscle activation may at least partly underpin voluntary force enhancement; this enhancement has thus recently been called post-activation performance enhancement (PAP) to distinguish it from “classical” PAP(Finlay et al., 2021).

Post-activation potentiation (PAP) is a physiological phenomenon that involves the enhancement of muscular performance following a conditioning activity. It refers to the temporary increase in muscle force production that occurs after a high-intensity muscular

contraction. The concept behind PAPE is based on the idea that a prior muscular contraction can induce changes in the muscle's neuromuscular system, resulting in improved subsequent performance. The mechanism underlying PAPE is believed to involve the phosphorylation of myosin regulatory light chains (RLCs) in the muscle fibers(Piper et al., 2020). This phosphorylation process leads to an increase in the sensitivity of the muscle fibers to calcium ions, which are essential for muscle contraction. As a result, the muscle fibers exhibit greater force production capabilities during subsequent contractions(Grange et al., 1993).

To induce PAPE, athletes typically perform a heavy resistance exercise or a plyometric activity before their main activity or event. The conditioning activity should be sufficiently intense to stimulate the muscle fibers without causing excessive fatigue. The specific exercise used for conditioning depends on the athlete's sport and the muscle groups involved. The duration of the PAPE effect varies among individuals and can range from a few seconds to several minutes(Tillin & Bishop, 2009). The optimal timing between the conditioning activity and the subsequent performance varies as well and is influenced by factors such as the individual's training status, exercise type, and intensity. Generally, the time interval is around 3 to 10 minutes, although it may need to be adjusted based on individual responses and preferences(Cuenca-Fernández et al., 2022).

Athletes and coaches often use PAPE strategically to enhance performance in various sports and activities. The improved muscle force production can lead to benefits such as increased power output, speed, and jump height. However, it's important to note that PAPE effects can be variable, and not all individuals respond equally or consistently to this training technique. It requires careful experimentation and individualization to determine the optimal conditioning activity, timing, and recovery for each athlete. It's worth mentioning that PAPE should be implemented judiciously and integrated into a well-designed training program. Inappropriate use of PAPE, such as excessive fatigue or improper timing, can lead to decreased performance or increased injury risk(Jaffe, 2018).

Post-activation potentiation (PAPE) can be used to enhance performance in various sports and activities. By taking advantage of the temporary improvements in muscular force production and neural activation that occur after a conditioning activity, athletes can potentially achieve higher levels of power, speed, and overall performance(Tillin & Bishop, 2009). PAPE can be particularly beneficial for activities that require high levels of power and explosiveness, such as sprinting, jumping, and throwing. By incorporating heavy resistance

exercises or explosive movements into the warm-up, athletes can enhance their muscle force production capabilities. This can lead to improved sprint times, higher jump heights, and greater throwing distances(Krzysztofik et al., 2021).

PAPE can be utilized in weightlifting and strength training to optimize performance during subsequent lifts. By performing a heavy lift or a series of heavy lifts before the main lifts or exercises, athletes can prime their neuromuscular system and potentially lift heavier loads or perform more repetitions. This can be especially beneficial in competitive weightlifting, powerlifting, or sports that require high levels of strength. PAPE can be integrated into warm-ups by incorporating sport-specific movements that mimic the actions and demands of the activity. For example, a badminton player can perform explosive vertical jumps or quick lateral movements as part of their warm-up routine. By engaging the relevant muscle groups and enhancing their force production capabilities, athletes can improve their agility, quickness, and overall performance in their respective sports. PAPE can also be utilized in interval training or high-intensity workouts. By performing a short burst of high-intensity exercise, such as sprinting or a maximal effort exercise, athletes can activate their neuromuscular system and potentially achieve greater power output and performance during subsequent intervals. This can be particularly beneficial in sports that involve repeated bursts of high-intensity efforts, such as soccer, basketball, or track and field events.

Post-activation potentiation (PAPE) can be effectively used during warm-up routines to enhance performance during subsequent activities or events. By incorporating PAPE into the warm-up, athletes can take advantage of the temporary improvements in muscular force production and neural activation that occur as a result of the conditioning activity. A typical warm-up routine begins with a general warm-up, which includes light aerobic activities like jogging or cycling. This helps increase body temperature and blood flow, preparing the body for more intense movements. Following the general warm-up, specific activation exercises can be performed to target the muscle groups involved in the subsequent activity. These exercises should be dynamic and focus on activating the muscles rather than fatiguing them. Bodyweight squats, lunges, or explosive movements like medicine ball throws are examples of activation exercises.

After the activation exercises, a conditioning activity is performed to induce the PAPE effect. This exercise should be challenging but not excessively fatiguing. It specifically targets the muscles athlete want to potentiate. Examples of conditioning activities include heavy

resistance exercises like squats or deadlifts, or explosive movements like box jumps or kettlebell swings. The goal of the conditioning activity is to stimulate the neuromuscular system and induce the PAPE effect. Following the conditioning activity, an appropriate recovery period is essential to maximize the PAPE effect. The duration of the recovery period depends on various factors, including the individual's training status and the specific conditioning activity performed. Typically, a recovery period of around 3 to 10 minutes is recommended. During this time, the body has a chance to recover while still maintaining the enhanced neuromuscular state induced by the conditioning activity. After the recovery period, the athlete can proceed to the main activity or event for which the warm-up is preparing them. The PAPE effect should enhance muscular performance, resulting in increased power, speed, or jump height during the subsequent activity.

There are several studies in which post activation potentiation is induced using weight training and plyometrics, very few studies have been conducted using resistance bands. Resistance bands are easy to carry and can be easily used in warm-up routines to induce PAPE. However, these studies only investigated the immediate effects of resisted warm-ups on short bouts of performance tests. It is unknown how such beneficial effects translate to key physical components during badminton match play.

Statement of the Problem

To analyse the effect of band induced post-activation performance enhancement on physical and skill-related markers during a simulated badminton match play.

Delimitations

Delimitations are specific areas or boundaries which are set by the researchers based on administrative feasibility, financial limits and purpose to be attained.

- The study will be delimited to the simulated badminton match play.
- The study will be delimited to sub-elite players.
- Study will be delimited to only15 badminton players.
- The study will be delimited to **7** variables.

Hypothesis

H1: There will be a significant difference between all the 3 protocols, with most PAPE induced in protocol 3 (RPEB2).

H2: A significant Within difference in physical and skill-related performance markers is hypothesized in repeated testing done after every exercise bloc.

H3: There will be a significant improvement in Protocol 3 (RPEB2) when compared to Protocol 1 (CON) and Protocol 2 (RBB).

Definition and explanation of the terms

Post-activation potentiation- post-activation potentiation (PAPE) is a physiological phenomenon where muscular performance is temporarily enhanced following a high-intensity contraction. It involves an increase in muscle force production due to changes in the neuromuscular system, leading to improved power, speed, and performance during subsequent activities or events.

Resistance band- A resistance band, also known as an exercise band or fitness band, is a versatile elastic band typically made of rubber or latex that is used for strength training, rehabilitation exercises, and flexibility training. It offers resistance when stretched, providing a challenging workout for various muscle groups.

Simulated match play- Simulated match play refers to a training method or activity designed to replicate the conditions and demands of an actual competitive match in a controlled practice environment. It involves creating scenarios and situations that closely resemble real-game situations.

Significance of the study

1. The study will help badminton players improve their performance.
2. The study will be helpful in developing warm-up routines for badminton players.
3. The study will give insight about effective use of resistance band for inducing PAPE.
4. The study will provide knowledge about effectiveness of PAPE at different time intervals.

CHAPTER- II
REVIEW OF RELATED LITERATURE

Eroğlu, Ş. (2022). The aim of this research was to determine the optimal resting time interval for producing the highest explosive power after the Post-Activation Potential (PAP) protocol. The study involved a group of participants with an average age of 19.31 years, height of 170.31 cm, weight of 69.09 kg, and maximal squat one repetition performance (1-RM) of 86.36 kg. Measurements were conducted over five separate days with 72-hour intervals. The results revealed that a 15-second rest period after the PAP protocol had a negative impact on explosive strength performance. However, there were no statistically significant differences observed between rest time intervals of 3 minutes, 6 minutes, and 9 minutes. In conclusion, the most suitable resting time for enhancing the explosive strength performance of wrestlers following the PAPE protocol falls within the range of 3 to 9 minutes.

Barbosa, T. M., Yam, J. W., Lum, D., Balasekaran, G., & Marinho, D. A. (2020). The objective of this study was to analyze the kinetics and kinematics of the front-crawl arm-pull before and after post-activation potentiation (PAP), as well as investigate the associations between variables related to arm-pull kinetics. Twelve male competitive swimmers were randomly assigned to two different warm-up conditions: a non-PAP control condition and an experimental condition involving PAP. The PAP warm-up consisted of two sets of five arm-pulls with resistance bands using both upper limbs. After an eight-minute rest, participants performed a 25m all-out trial of front-crawl arm-pull. Kinetic parameters such as peak thrust, mean thrust, and thrust-time integral, as well as kinematic parameters including speed and speed fluctuation, were measured using a customized system with pressure sensors, speedometer, and underwater camera. The results showed a significant and large improvement in arm-pull kinetics following the PAP warm-up ($p < 0.054$, effect size d between 0.50 and 0.74). However, there were non-significant and small effects of PAP on speed ($p = 0.307$, $d = 0.18$) and speed fluctuation ($p = 0.498$, $d = 0.04$). Furthermore, there were significant and large correlations between the kinetic variables (correlation coefficients ranging from 0.51 to 0.90, $p < 0.088$), indicating that these variables can be used interchangeably to characterize thrust. In conclusion, warm-ups incorporating PAPE conditioning sets lead to a significant improvement in arm-pull thrust but have only a small

impact on performance. The correlated nature of the kinetic variables suggests their interchangeable use in practical applications.

Lum, D., & Chen, S. E. (2020). The purpose of this study was to determine the optimal variable resistance (VR) intensity for inducing post-activation potentiation (PAP) in loaded countermovement jumps (LCMJ). Eleven male athletes participated in one familiarization session and four testing sessions. They performed their own pre-competition warm-up, followed by baseline measurements of two countermovement jumps (CMJ). Subsequently, they performed either unloaded CMJ (UCMJ) or LCMJ with one of three VR intensities: Orange (6.7±0.6 kg), Red (14.0±0.9 kg), and Blue (24.0±1.4 kg), in random order, before performing two more CMJ for post-test measurements. Each testing session was separated by at least 48 hours. The results showed a significant increase in jump height across all conditions, with no significant difference in the change in jump height between conditions. Comparing Orange with the other conditions revealed small to moderate effects. Peak force and velocity increased significantly in the Red and Orange conditions. The change in jump height was significantly correlated with the change in peak velocity and peak power. In conclusion, both UCMJ and LCMJ were effective in acutely improving jump height, and an intensity level of approximately 10% of body weight provided by VR appeared to be the optimal resistance level.

Terraza-Rebollo, M., & Baiget, E. (2020). The purpose of this study was to investigate the impact of post-activation potentiation (PAP) on serve velocity and accuracy in young competition tennis players using complex training with different upper and lower body heavy load resistance exercises. Fifteen tennis players (9 boys and 6 girls, average age 15.6 ± 1.5 years) participated in 1 control session and 3 experimental sessions using a crossover-randomized design. The experimental sessions included bench press (BP), half squat (HS), and a combination of BP and HS exercises, while the control trial had no exercises. The heavy load resistance exercises consisted of 3 sets of 3 repetitions at 80% of the one-repetition maximum (1RM) with maximum speed. Serve velocity and accuracy were assessed by having participants perform 32 flat serves after the exercises, divided into 4 sets of 8 serves at different recovery times (0, 5, 10, and 15 minutes post-exercise). The results showed no significant differences in ball velocity and accuracy across the recovery times and

exercises compared to the baseline measurements. Therefore, it was concluded that complex training using heavy load resistance exercises is not an effective method for inducing post-activation potentiation or enhancing serve accuracy in young competition tennis players.

Maloney, S. J., Turner, A. N., & Miller, S. (2014). This study aimed to investigate the acute effects of a loaded dynamic warm-up on change of direction speed (CODS) in elite badminton players, which had not been previously examined. Eight participants performed vertical countermovement jump and CODS tests before and after three different warm-up conditions: wearing a weighted vest equivalent to 5% body mass, 10% body mass, or no weighted vest (control). Vertical jump and CODS performances were measured at 15 seconds, 2 minutes, 4 minutes, and 6 minutes post-warm-up. The results showed significant improvements in both vertical jump and CODS following all warm-up conditions. There were no differences in post-warm-up vertical jump performance among the conditions. However, CODS was significantly faster after the 5% and 10% loaded conditions compared to the control condition. Furthermore, peak CODS performances, regardless of recovery time, were faster following the 10% loaded condition. In conclusion, the study revealed that a loaded warm-up enhanced CODS but did not affect vertical jump performance in elite badminton players.

Aandahl, H. S., Von Heimburg, E., & Van Den Tillaar, R. (2018). The aim of this study was to investigate the effects of kicking with elastic resistance during warm-up on post-activation potentiation (PAP) and subsequent explosive roundhouse kicking performance. Sixteen participants with a background in kickboxing or Taekwondo performed two warm-up strategies followed by three test kicks. Kicking velocity and muscle activity were measured using 3D motion capture and electromyography. The results showed that kicking with elastic resistance during warm-up led to a 3.3% increase in roundhouse kicking velocity and increased muscle activity in the vastus medialis and rectus femoris muscles. These findings suggest that incorporating kicking with elastic resistance into the warm-up routine can positively impact kicking performance in a roundhouse kick.

CHAPTER- III
METHODOLOGY

This chapter provides a detailed description of the process employed to choose participants, select variables, establish criterion measures, administer tests, gather data, and employ statistical techniques for data analysis.

Research Design

A randomised crossover design will be used.

Selection of subjects

- For this particular study, 15 subjects will be selected using purposive sampling technique.
- Subjects (Age: 16-24years) should have training experience of at least 3 years with full-time strength and conditioning training (minimally two sessions a week).

Selection of variables

- Counter movement jump
- Standing broad jump
- 30m sprint
- 10m
- Medicine ball throw
- Change of direction speed

Criterion measures

The variables will be measured by the following instruments and methods:

S.No	Variable	Equipment	Unit
1	Countermovement jump	My Jump App	cm
2	Standing broad jump	Measuring tape	Meter
3	30m sprint	Stopwatch	Second

4	10m sprint	Stopwatch	Second
5	Medicine ball throw	Medicine ball	Meter
6	Change of direction speed	Badminton specific footwork test	seconds

Administration of the test and collection of data

Subjects will be required to attend a total of 4 sessions, including one familiarization and three testing sessions. During the familiarization session, subjects will be briefed on the experimental procedures, familiarized with the various exercises of the three warm-up conditions. The determination of the load and type of resistance bands to be used will also be trialled during this session. Lastly, players will perform a condensed version of the experimental trial. They will complete a baseline test for each variable, followed by one exercise block of the simulated match play protocol (SMP), which consisted of 5 min of simulated rallies followed by test of each variable. Each of the four testing sessions will be separated by at least 48 hours.

On subsequent sessions, players will perform their randomly allocated protocol. Four minutes after the warm-up, the players will perform the baseline performance tests. Subsequently, the players rested for one minute and began to perform the simulated match play.

Protocols

1.Controlled Protocol (CON)

Under the controlled protocol (CON), players will perform warm-up routine of 24 exercises using their own bodyweight (no external resistance) in all the exercises (1-24). Exercise nos. 1 to 19 will be performed at the player's own pace, with no more than 15 s of passive recovery between exercises. Then player will perform sport-specific plyometric exercise nos. 20 to 24 without external resistance (CON). These exercises will be performed with maximal effort, and with 1 min of passive recovery between each set of exercise. Four minutes after the warm-up routine the players will perform baseline performance tests. Subsequently, players will be given rest for 1 minute and then they will perform the stimulated match play. Players will be provided with a 30 s rest at the end of the 5 min simulated rallies to prepare for the performance tests, and 1 min of passive rest after the performance tests before

proceeding to the next exercise block. Players will perform performance tests before block 1 and after every four blocks. (figure 1)

2. Resistive plyometric exercises in warmup (RBB)

Under the resistance band before SMP protocol (RBB), players will perform warm-up routine of 24 exercises. Exercise nos. 1 to 19 (without external resistance) will be performed at the player's own pace, with no more than 15 s of passive recovery between exercises. Then player will perform sport-specific plyometric exercise nos. 20 to 24 with resistance band. These exercises will be performed with maximal effort, and with 1 min of passive recovery between each set of exercise. Four minutes after the warm-up routine the players will perform baseline performance tests. Subsequently, players will be given rest for 1 minute and then they will perform the stimulated match play. Players will be provided with a 30 s rest at the end of the 5 min simulated rallies to prepare for the performance tests, and 1 min of passive rest after the performance tests before proceeding to the next exercise block. Players will perform performance tests before block 1 and after every four blocks.(figure-2)

3. Resistive plyometric exercises post SMP block 2 (RPEB2)

Under the resistance band exercises post SMP Block 2(RPEB2), players will perform warm-up routine of 24 exercises. Exercise nos. 1 to 19 (without external resistance) will be performed at the player's own pace, with no more than 15 s of passive recovery between exercises. Then player will perform sport-specific plyometric exercise nos. 20 to 24 with resistance band. These exercises will be performed with maximal effort, and with 1 min of passive recovery between each set of exercise. Four minutes after the warm-up routine the players will perform baseline performance tests. Subsequently, players will be given rest for 1 minute and then they will perform the stimulated match play. Players will be provided with a 30 s rest at the end of the 5 min simulated rallies to prepare for the performance tests, and 1 min of passive rest after the performance tests before proceeding to the next exercise block. Players will perform performance tests before block 1 and after block 1 and block 2. After performing block 2 and giving performance test players will perform exercise nos. 20 to 24 with resistance band and then perform the block 3. Subsequently, performance tests will be performed after block 3 and block 4. (figure-3)

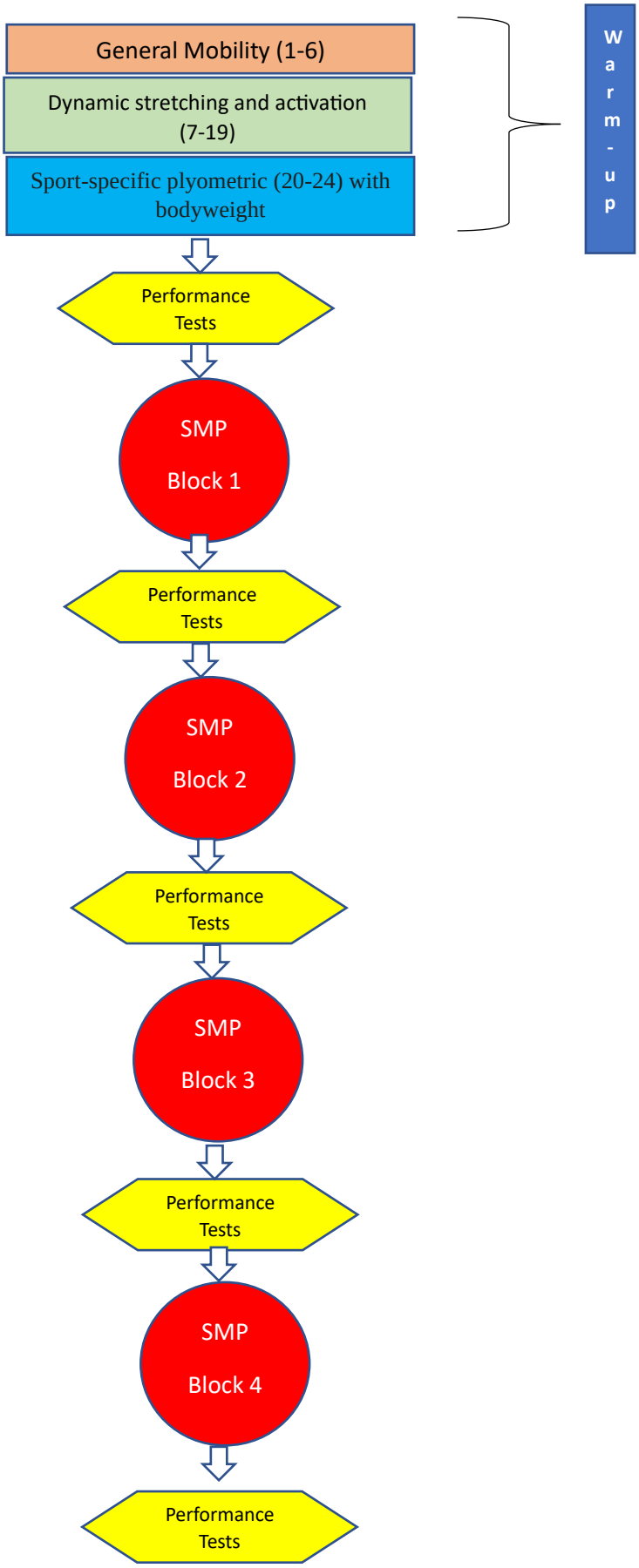

Figure 1-Controlled Protocol (CON)

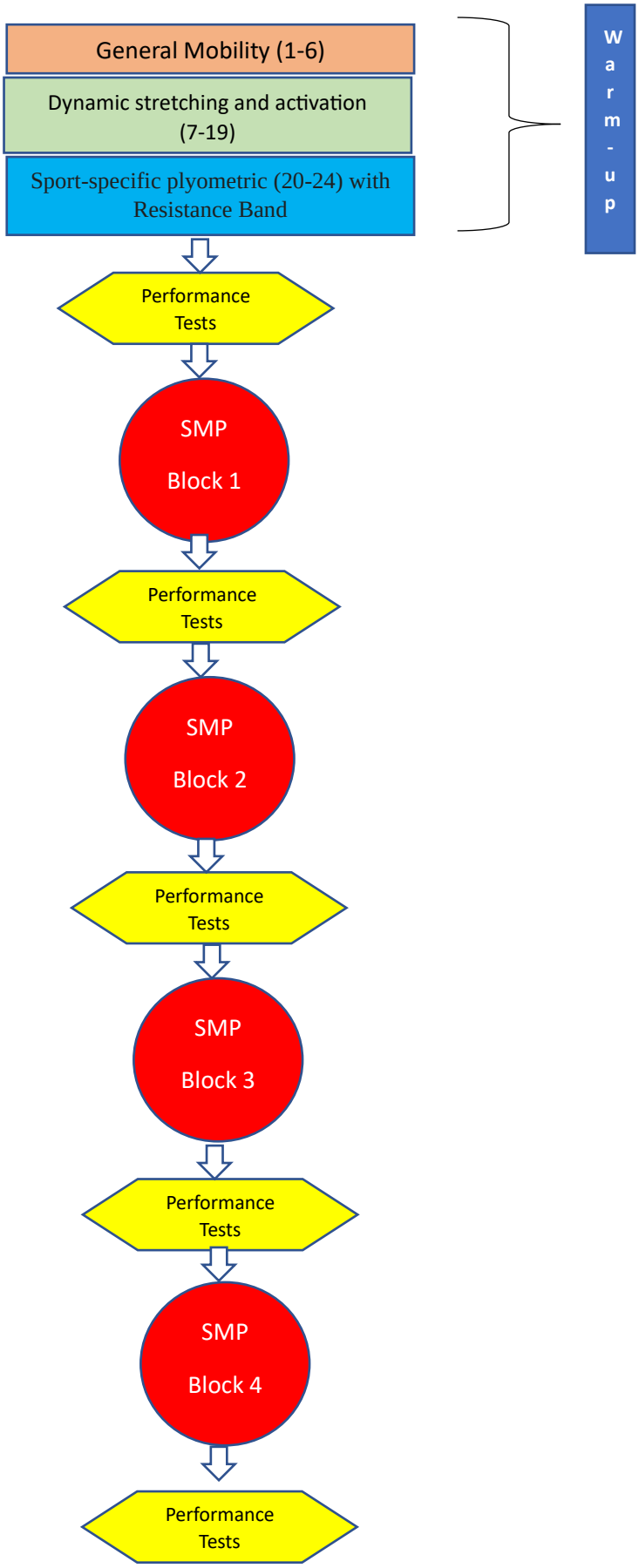

Figure 2- Resistive plyometric exercises in warmup (RPE)

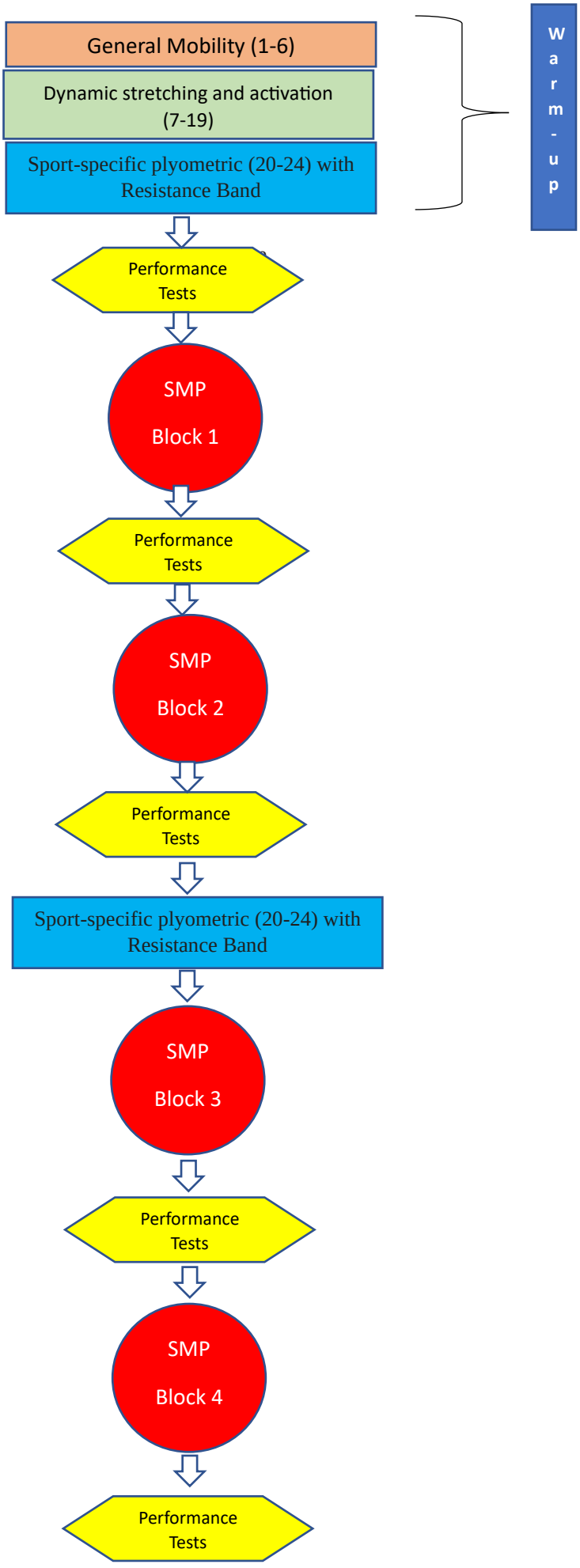

Figure 3- Resistive plyometric exercises post SMP block 2(RPEB2)

Simulated Match Play

The SMP will consist of 4 exercise blocks. Each exercise block included 4 min of simulated rallies, followed by performance tests. The 4 min of simulated rallies will incorporate rallies of 5 shots where shuttlecocks will be fed by a feeder from the opposite side of the court to the various zones (Figure 2): Zone 1 (Z1), Zone 2 (Z2), Zone 3 (Z3), and Zone 4 (Z4). Each 1.5 m × 1.5 m zone will be demarcated by small tape markers on the court. For each rally, 5 shuttlecocks will be fed to players at a 2 s interval (dictated by beeping sounds) in a random order. Players will return with a net shot or underhand clear shot from the feeding shots in Z1 and Z2, and with overhead clear shot from Z3 and Z4. Players will be provided with a 30 s rest at the end of the 4 min simulated rallies to prepare for the tests, and 1 min of passive rest after the tests before proceeding to the next exercise block.

Statistical analysis

- Data will be analyzed using statistical software (IBM SPSS).
- Descriptive statistics will be used.
- To test the Between group (CON vs RBB vs RPEB2) and With-in group (Baseline vs block1 vs block2 vs block3 vs block4) 3x5Mixed ANOVA will be used.

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Phase	Exercises	Repetitions/Distance
General Mobility (1-6)	1. Jogging	4 x 10 m
	2. Backpedal	4 x 10 m
	3. Side Shuffle (alternate lead foot)	4 x 10 m
	4. Carioca (alternate lead foot)	2 x 10 m
	5. Jogging with high knees	2 x 10 m
	6. Jogging with butt kicks	2 x 10 m
Dynamic Stretching and Activation (7-19)	7. Walking on toes	2 x 10 m
	8. Walking on heels	2 x 10 m
	9. Walking hip circles (medial to lateral)	2 x 10 m
	10. Walking hip circles (lateral to medial)	2 x 10 m
	11. Walking deep lunges	2 x 10 m
	12. Thoracic rotation in lunge position (both sides)	10 reps per leg
	13. Frontal leg swings (both legs)	10 reps per leg
	14. Lateral leg swings (both legs)	10 reps per leg
	15. Alternate side lunges	5 reps per leg

	16. Wall angels	10 reps
	17. Dynamic arm swings (forward and backward)	10 reps
	18. Side arm swings	10 reps
	19. Fast feet running	2 x 10 m
Sport-specific plyometric(20-24)	20. Plyometric push-ups	1 x 10 m
	21. Overhead smash	2 x 5 reps
	22. Bilateral countermovement jumps	2 x 5 reps
	23. Alternating split squat jumps	5 reps
	24. 2-corners shadow movement	2 x 2 rounds